Microprobe Instrument Specification
for
University of Oregon
September 3, 2004
(this specification supersedes all prior specifications)

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A. General Requirements

The vendor shall furnish all facilities, labor, and materials to provide goods and services in accordance with the terms and conditions described in this specification for both the hardware and software. The Vendor shall maintain an inventory of spare and repair parts and such tools and instruments as necessary to properly and efficiently maintain the equipment for the life of the microprobe itself, at least 15 years. Spare parts and consumables must be obtainable within a maximum of 10 working days after a purchase order number is received by the Vendor. The specifications listed in this document are the **minimum** requirements for the University of Oregon electron microprobe.

Please take special precautions in arranging shipping for the instrument as a dropped instrument will not be accepted. In addition copious use of tilt and drop indicators must be affixed to the instrument and all associated crating to insure that the instrument is not subjected to any stresses during the transport of the instrument from the manufacturer.

Please provide a detailed **competitive** price quotation for each major component, device or feature. Please quote each price and the system total on a **duty free basis (no sales tax)** and inland transportation costs) as we will be applying for a customs duty exemption. The prices quoted should reflect any educational discounts that can be applied to a non-profit educational organization purchase.

The payment plan will be negotiated but the following schedule is suggested:

50% on delivery to UofO (Eugene, OR)
30% on initial acceptance (including meeting Vendor's specifications)
20% on final acceptance (at least six months after initial acceptance and including Vendor's specifications)

Please include in the quotation any additional equipment or software and pricing that will be required to efficiently operate **all** instrument features specified in this document if they are not standard equipment or not explicitly stated in the specifications.

A catalog and current price list of all spare parts and assemblies shall be provided by the Vendor with the instrument.

Quotation Point Evaluation System
For the purposes of evaluating the Vendor's quotation there will be three areas of criteria to evaluate. The Vendor that meets all mandatory requirements AND the highest point total for desirable requirements, will win the bidding process and be awarded the purchase order.

1. **Mandatory requirements**
   The quoted instrument must meet these requirements completely and without exception.

2. **Desirable requirements**
   The quotation will be awared points for the quoted instrument that meets the "desirable" requirement (approximately 1000 points)

3. **Price points**
   The quotation will be awarded points based on the difference in price between the Vendor's quote and the lowest quotation received. The Vendor whose total price is the lowest will be awarded the full number of price points (1000 points). Vendor's whose quotation's total price is higer than the lowest will receive a prorated number of price points in a relational manner as described here:

Points awarded = $\frac{lowest\,bid\,price}{actual\,bid\ price} \times 1000$

B. Inclusion of Vendor's Technical Proposal into this Specification

The Vendor's technical performance specification proposal entitled, [ ] dated [ ], is incorporated by reference and made a part of this contract. In the event of any inconsistency between the provisions of this contract and the Vendor's technical proposal, the contract provisions in this document take precedence.

C. Preliminary Testing by Vendor Prior to Shipping

Documentation of performance in accordance with following **preliminary** specifications shall be provided by the Vendor before shipping the instrument. The seller shall provide the necessary personnel, equipment and facilities to conduct these same acceptance tests and the other specifications described in section G. below entitled "Technical Specifications" on the installed instrument, unless this document specifically states that UofO (University of Oregon) shall provide the items required.

Preliminary Performance Specifications to be Received by UofO Prior to Instrument Shipping (**the instrument shipment will not be accepted** by the UofO until documentated demonstration of the following items have been received and reviewed by UofO personel):

- Electron gun specifications 1c
- Electron column specifications 2b, 2c, 2j
- Wavelength spectrometer specifications 3i
- Secondary and backscattered specifications 4a, 4c
- Light optical specifications 5d, 5e
- Vacuum/UPS specifications 6e
- Specimen chamber specifications 7e
- Stage specifications 8a, 8b
- Interface specifications 9a, 9b, 9c, 9d
- Software specifications 10b

D. Installation and Acceptance Testing

Acceptance of the instrument shall be based upon completion of installation and after testing of instrument hardware performance ***on site*** at UofO, Cascade Hall, Eugene, OR by personnel selected by UofO.

The instrument shall meet ALL specifications described in this specification and the Vendors included proposal (with appropriate calculated scale factors at UofO's normal operating condition of 15 KeV). The instrument shall meet the specifications before **initial acceptance** and ***again six months after acceptance*** **(final acceptance). The last payment is to be made after final acceptance is completed.**

The acceptance tests shall be performed on samples provided by John Donovan or his designated assistant at UofO, including thin sections, polished mounts of minerals and oxides and metal elements and alloys. Final payment will be made after all acceptance tests have been completed and the instrument meets all specifications in this document.

The Vendor shall provide all parts, materials, labor, and transportation required to perform **preventive and remedial** maintenance on the instrument during the **installation and acceptance testing** period (up to one year or until the instrument has met all acceptance tests, **whichever is longer**). The maintenance services shall also be performed in accordance with the terms, conditions, and statement of work set forth herein. The Vendor's warranty shall not begin until the instrument has passed all acceptance tests and meets all technical specifications described in this document. Any consumables (filaments, light bulbs, etc.) required to run the instrument during the acceptance testing shall be supplied by the Vendor at no extra cost to UofO.

Preventive maintenance shall include, but not be limited to, cleaning, adjusting, lubricating, inspecting, and testing procedures to keep the equipment in good operating condition, preclude equipment failures to the greatest extent possible, and extend useful equipment life. It includes running of all diagnostics, and repair and replacement of all defective parts.

Remedial Maintenance shall include replacement of parts that do not meet the specifications or requirements described in this document. This includes all transportation, labor and parts required for the parts replacement or upgrade.

All parts, materials, and components, including expendable items, shall be replaced when necessary during the installation and acceptance testing period at no additional cost to the University. Replaced parts shall become the property of the Vendor.

The work to be performed shall be in accordance with the original equipment Vendor's specifications and recommendations. All services are to be performed by competent personnel, experienced and highly qualified to provide required services in accordance with the best commercial practices, without unnecessary delays or interference with University functions.

E. On Site Training

Training for one designated personnel for the instrument in the operation of all hardware and software shall be provided at destination. Training shall be approximately two weeks in length, starting once the initial acceptance of the instrument is completed and to be conducted during regular business hours Monday through Friday.

F. Documentation

Documentation manuals shall be provided for the instrument, that clearly and completely describe hardware and software operation, troubleshooting, user maintenance and user servicing of all components of the microprobe. All manuals for Vendor supplied third-party items shall be provided. The manuals must be originals or high quality copies and must also be completely legible and readable without magnification or other reading aid.

General interconnect and wiring schematics **in English** and spectrometer, sample stage and sample holder(s) mechanical drawings with dimensions and tolerances shall be provided by the Vendor. Detailed instrument schematics shall be provided from the vendor in the event that UofO might make future modifications. **A complete list of all o-rings used shall be provided, with exact measurements and tolerances and materials and where they are used in the instrument.**

All vendor supplied TCP/IP and/or dynamic link library (DLL), or COM/Active-X interfaces and functions shall be completely documented so that UofO may write programs in C, C++ or Visual Basic to access them. Several code examples shall be supplied to demonstrate the ability to interface to the Vendor's instrument interface and all specified microprobe functions. See specification 9d.

All manuals for Vendor supplied third-party items such as the computer boards and interface cables shall be provided. All documentation shall be provided **in English.**

G. Technical Specifications and Requirements

The University of Oregon requires a state-of-the-art, fully automated electron microprobe to conduct its research programs. This microprobe shall be able to both qualitatively and quantitatively analyze and image all elements from Be to U and must meet the following additional MANDATORY requirements (all requirements are MANDATORY unless noted as ***desirable***). Desirable requirements will be assigned points. Total points for desirable requirements will be 2000 points.

1. Electron gun :

a) beam current stability 0.1 % or less per hour (+/- 0.05 %) and 0.6 % or less per 12 hours (+/- 0.3 %) and 1.0 % or less in 24 hours (+/- 0.5 %) as measured at 15 KeV and 10 nA while repeatedly inserting the faraday cup approximately once per minute

b) gun to be automatically biased as accelerating voltage is changed from 1 keV to 30 keV

c) **regulated** current range from at least 1 nanoamps to 200 nanoamps (1 to 500 nA ***desired***) with a linearity of better than 0.2% as measured using a NIST tracable electrometer

Desired: 1 to 500 nA regulated beam current range: 25 points

d) tungsten filament with ion pump backing for gun and Whenelt volume. Typical operating life of the filament shall average 1000 hours or better at normal filament current, emission and saturation conditions (0.5 micron beam diameter, 80 microamps emission and 50 nA beam current at 15 KeV measured using a 99% SE signal intensity profile criteria)

2. Electron column :

a) accelerating voltages regulated from 1 KeV to 30 KeV (1 to 40 Kev desirable) in at least 1 KeV steps

Desired: 1 to 40 keV regulated high voltage range: 25 points

b) **absolute accuracy** of accelerating voltage **at 3, 5, 10, 15 and 20 KeV** must be less than 0.5 % (+/- 0.25%) from the nominal accelerating voltage or within 7.5 volts at 3 KeV, 12.5 volts at 5 KeV, 25 volts at 10 KeV, 37.5 volts at 15 KeV and within 50 volts of 20 KeV as determined using the Duane-Hunt limit test on EDS (when calibrated on known x-ray line energies, Eg, Cu Ka, Cu La)

c) high voltage instability must be no more than +/- 0.005 % per hour (+/- 50 ppm) as determined by repeated Duane-Hunt limit test on EDS (with Cu Kα/Lα calibration) or equipment supplied by UofO (see 2b)

d) beam diameter shall be less than 0.6 microns at 15 KeV and 100 nA defined as 99 % of primary electrons as measured across a synthetic interface and measured using a signal from the SE detector

e) stray beam measured using a 100 micron W or Mo aperture target in a Ti target block to produce W or Mo Lα and Ti Kα k-ratios (both EDS and WDS) less than 0.0001 (0.01 wt % or 100 ppm) using a 100 nA beam and at operating voltages from 5 KeV to 30 KeV

f) beam diameter shall be adjustable from focus to 100 microns and shall focus/defocus in a symmetrical manner when the objective lens current is varied and at 10, 15, 20 and 25 kev without column or aperture readjustment

g) beam current shall not change more than 0.5 % (+/- 0.25 %) and the SE image shall not vibrate or shift more than +/- 1 micron while the spectrometers are driven over their full range when a point of interest is viewed under SE at 10,000X.

h) beam focus and position shall not visibly move during condenser lens adjustment as viewed at 300-400X on a fluorescent sample

i) final apertures must be externally selectable and have external X-Y adjustments

j) the beam monitoring aperture (faraday) current variation shall be less than 0.3 % (+/- 0.15 %) when measured on both a pure carbon sample and on a pure Fe sample at both 10 KeV and 25 KeV @ 50 nA beam current and enough replicate measurements to achieve sufficient precision (the stage position (stepper motor winding circuits) shall have an effect on the beam current of less than 0.1% (+/- 0.05%)

k) the carbon contamination intensity rate of change shall be less than 0.01% C/minute on a polished Cu sample for 30 minutes at 20 KeV and 100 nA with a 10 micron focused beam at all times in the instrument **using an anti-contamination technology (running continuosly on a 100% duty cycle using gas bypass to maintain an even temperature) consisting of a chilled baffle installed over the diffusion pump which is maintained at –40 degrees or below using a Freon (or other compressed working fluid). The device should have a separate resevior connected to the baffle that can be optionally filled with LN2, when desired for even lower contamination rates, by the operator.**

l) absolute accuracy of all magnification readouts or displays at 5, 10, 15, 20, 25 and 30 KeV must be less than 2 % (+/- 1 %) at 100x, 200x, 500x, 1000x, 2000x, 5000x, and 10,000x, using NBS/NIST standard 484a or other appropriate magnification standards. Additionally the scan rotation must be maintained within 0.5 degree rotation for each magnifiation change as specified above at both 5, 10 and 30 keV.

m) there shall be no window between the spectrometer housings and the column vacuum chambers, or written documentation must be provided demonstrating the tranmissibility of N Ka (Nitrogen K-alpha) x-ray line; **if column windows are required, the vendor shall provide two spare windows for each thin column window spectrometer.**

n) the instrument shall be provided with a manual aperture turret or wheel to control the x-ray intensity input (and provide backscatter electron and contamination protection using a Be window for the atmospheric thin window) from the probe to an EDS detector system. In addition, an external beam control option is to be provided by the Vendor, for use by the third party EDS digital beam control hardware. All mechanical flanges and/or adapters required for installation of the third party EDS hardware is to be provided by the Vendor.

The Vendor shall provide detailed mechanical drawings showing the EDS mounting system, aperture and port configuration for possible collimating apertures to be manufactured and installed by UofO.

3. Wavelength spectrometers :

a) five (5) vertical mounted (linear optical encoding desired but not required) wavelength dispersive X-ray spectrometers using xenon sealed (XePC) or P-10 flow (GFPC) at 1.0 atmospheres regulated detectors with (externally adjustable detector slits from 300 - 3000 microns, if they are standard equipment) and a system for stray electron reduction (filter magnets or column windows, etc.) in the spectrometer mechanism to minimize noise from secondary electrons.

Large area crystals (LiF and PET) must maintain the similar spectral resolution requirements as for normal area crystals (e.g, both normal and large area crystals must use the same focal circle diameter) and should produce at least 30% greater count rates than normal sized crystals as measured at the upper range of the spectrometer travel (high sin-theta positions). The crystal resolution specification is detailed in section 3. H

All synthetic multi-layer "crystals" must be optimized for reduction of higher order reflections and minimize production of "fringe" reflections from "front to back" diffractions.

The following spectrometer configuration is required :

Desired: linear optical encoding for all spectrometers: 100 points

- #1 PET/TAP//LDE (OV-60A or equivalent optimized for O kα)/LDE (OV-098N or equivalent optimized for C kα) GFPC w/ 10 - 30μg/cm^2 (0.1 - 0.3μ) polypropylene window (**4 crystal spectrometer**)

- #2 PET/TAP/LDE (OV-080E or equivalent optimzed for N kα)/LDE (OV-130H or equivalent optimized for B kα) GFPC w/ 10 - 30μg/cm^2 (0.1 - 0.3μ) polypropylene window (**4 crystal spectrometer**)

- #3 PET/TAP GFPC w/ 20 - 30μg/cm^2 (0.1 - 0.3μ) polypropylene window, large area crystal for PET required, (large area crystal for both PET AND TAP **desirable**)

  Desired: large area crystal for both PET AND TAP: 50 points

- #4 PET/LiF XePC **or** 45 PSIA P-10 GFPC w/ 1.0µ Be window, large area crystal for LiF required, (large area crystal for both PET AND LiF **desirable**)

  Desired: large area crystal for both PET AND LiF: 50 points

- #5 PET/LiF XePC **or** 45 PSIA P-10 GFPC w/ 1.0µ Be window

- the manufacturer shall supply an **additional 4 blank crystal mounting backs** for standard LDE (multi-layer) configuration, suitable for use by UofO to mount experimental LDE analyzers

b) high speed (limit to limit in 30 seconds), low electronic noise spectrometer motors (DC servo motors ***desired*** and limit to limit in 20 seconds or less is ***desired***). While spectrometer x-ray system is counting and beam is off, **there shall be less than 0.1 counts per second detected** while the spectrometer motors are moving for each spectrometer and simultaneously moving.

Desired: low electronic noise, low vibration spectrometer DC servos with 20 second limit to limit travel: 50 points

c) allow simultaneous use of all 5 WDS spectrometers, electron imaging (SE and BSE), EDS, reflected and transmitted light optics

d) crystals must automatically flip from any spectrometer position using computer control and return to the original position

e) reproducibility of spectrometer repeatability shall meet the following criteria using the LiF, PET and TAP crystals measuring Fe and Ca on LiF, Si and Ca on PET, and Mg and Si on TAP using 15 KeV and 30 nA beam current :

- with no detector slits or wide open slits, first determine the peak location and the location at one-half the maximum (either side) for each pair of elements on each crystal

- count for a period of time sufficient to achieve 0.5 % relative standard deviation.

- detune the spectrometer, position the spectrometer to the peak of element 1, position to the location at one-half maximum for element 1, position to the peak of element 2, position to the location at one-half maximum of element 2. Repeat 100 times from different starting points on the spectrometer. The peak intensities shall vary by less than 0.6 % (+/- 0.3 %) with 99 % confidence levels from the previous set and the one-half the maximum intensities shall vary by less than 1.2 % (+/- 0.6 %) at 99 % confidence levels **without** a backlash or re-peak procedure

- execute a crystal change (returning to the original crystal) on each spectrometer and immediately repeat the test in the paragraph above, Verify that the intensities measured vary less than 2 % (+/- 1 %) with 99 % confidence levels from the previous set **without a backlash or re-peak procedure**

f) agreement of simultaneous k-ratios between all WDS spectrometers on the same sample relative to the same standard must be better than 0.5 % (+/- 0.25 %) for

major elements concentrations when a counting period sufficient to achieve 0.2 % relative standard deviation or better is used at 15 keV. It is **desired** that the k-ratios agree within 0.3% (+/- 0.15%) for all TAP crystals when using a counting period sufficient to achieve 0.1% relative standard deviation or better is used at 15 keV.

Desired: k-ratio agreement for all TAP crystals within 0.3% (+/- 0.15%) using Mg Ka at 15 keV: 100 points

This test shall be performed using LiF, PET and TAP crystals measuring Fe Ka and Ca Ka on LiF, Ca Ka and Si Ka on PET, Si Ka and Mg Ka on TAP and O Ka and C ka on LDE multilayers the using suitable, metal, mineral or oxide standards and suitable beam currents and counting times

g) all analyzing crystals must be free from any visible fractures and/or defects

h) spectrometer resolution must be such that a measurement of the V Kα line on a 99.999% (metals basis) Ti sample (LiF crystal) yields an apparent k ratio of less than or equal to 0.005 when operating with a 20 KeV, 15 nA beam **under conditions at which measurements of Ti Kα yield the Vendor's and UofO's peak intensity and P/B ratio as specified in the table below :**

i) **each** supplied analyzing crystal count rate and P/B specification (as measured on pure metals unless otherwise noted) must meet or exceed **80%** of the Vendor's specifications **and 100% of the specifications in this document**:

Crystal	Element	CPS/uA	P/B	HV (kV)	Detector
LDE[1]	O kα (MgO)	5.0×10^4	80:1	10	GFPC
LDE[2]	N kα (AlN)	2.8×10^4	25:1	10	GFPC
LDE[3]	C kα (C)	5.6×10^5	80:1	10	GFPC
LDE[4]	B kα (B)	2.2×10^5	120:1	10	GFPC
TAP	F kα (CaF_2)	1.8×10^5	1500:1	20	GFPC
TAP	Mg kα (MgO)	2.8×10^6	1150:1	20	GFPC
TAP	Al kα	3.5×10^6	1050:1	20	GFPC
TAP	Si kα	3.8×10^6	900:1	20	GFPC
PET	Ti kα	2.6×10^6	600:1	20	XePC/3 atm FPC
PET	Cr kα	2.8×10^6	300:1	20	XePC/3 atm FPC
PET	Mn kα	4.0×10^6	350:1	20	XePC/3 atm FPC
LiF (200)	Ti kα	6.0×10^5	1000:1	30	XePC/3 atm FPC
LiF (200)	Fe kα	1.5×10^6	550:1	30	XePC/3 atm FPC
LiF (200)	Cu kα	2.0×10^6	340:1	30	XePC/3 atm FPC

[1] OV-60A or equiv
[2] OV-80E or equiv
[3] OV-98N or equiv
[4] OV-130H or equiv

j) verify that the instrument is aligned so that all crystals peak at an identical stage Z position within +/- 1 um by scanning the Z axis over a +/- 20 um range while counting x-ray signals with 0.5% counting precision or better

k) the background linearity as determined by measuring the off-peak background intensities for Ga and As on a GaAs sample and a Ge sample shall produce statistically identical results

l) the reproducibility of the ROM peaking (instrument based) method must be equivalent to the precision of the intensity measurements.

m) all flow and sealed proportional detectors and associated counting electronics shall have a deadtime constant no more than 3 usec. This will be determined using Si and Ti metal standards at 15 keV, and measured at beam currents from 10 nA to 200 nA for TAP and PET and PET and LiF crystal combinations. It is ***desirable*** that an electronic system be provided to "impose" a fixed or constant deadtime on the counting electronics using user specified values.

Desirable: an electronic system be provided to "impose" a fixed or constant deadtime on the counting electronics using user specified values: 50 points

4. Secondary and backscattered electron digital imaging system :

a) secondary image resolution of 70 angstroms (0.007 um) at 20 KeV or better using a tungsten filament on a sample of Au particles on carbon and a beam current of at least 100 pA. It is desired to meet this specification also at 300 pA

Desired: meet above spec at 300 pA: 50 points

b) backscattered electron spatial resolution of 150 angstroms (0.015 um) or better at 25 KeV shall be performed using a sample of Au particles on carbon using a tungsten filament and a beam current of at least 200 pA

c) backscattered electron atomic number resolution must be at least 0.1 Z at Z=29 or better (must easily contrast α/β brass sample) at **both 10 keV and 5 keV using a 5 nA beam**

d) slow, fast, TV, and programmable scan rates provided for secondary electron and backscattered electron image dedicated displays

e) SE and BSE image distortion as determined by viewing a ball bearing at 200X must be less than 2 % (+/- 1 %) on the CRT

f) dedicated monitors for imaging two video signals simultaneously, specifically both the BSE and SE (or CL) signals, 17"minimum diagonal (**desired 19**" diagonal minimum).

Desired: simultaneous BSE and SE display on dedicated 19" diagonal minimum monitors: 100 points

g) a high quality red-blue sensitive CL photomutiplier acquisition system suitable for beam (down to 150x) and stage scanning. This signal to be displayed (and acquired) simultaneously along with secondary and backscatter signals

h) signals for SE, BSE and CL, both the internally generated images and the external outputs for 3rd party imaging systems, must be electrically isolated from each other to meet the following specification. **When a high contrast image is present on each signal source (one at a time), the other two signal sources must not show any visible sign of the high contrast image when the gain and contrast are maximized on the other (no image) signals sources.**

i) the signal quality of the internal electron image system and the analog external outputs (for 3rd party imaging systems) must be of equal electronic quality in terms of noise and linearity

j) it is ***desired*** that the backscatter image must be easily visible even when the reflected light optics illumination is at normal brightness

Desired: backscatter image visible when using reflected light optics: 100 points

k) there shall be **dedicated** adjustment wheels or knobs for electron beam focus (fine and coarse) and magnification at all times

5. Light-optical image system :

a) normal incidence (90 degrees) high magnification (300-400x), reflected and transmitted (both plane and polarized light sources for transmitted light viewing, allowing observation of the sample both during positioning and WDS/EDS analysis and/or SE/BSE/x-ray imaging.

b) high resolution color television camera and dedicated monitor (18" diagonal minimum) as primary device for image observation. Variable optical zoom desired but not required.

Desired: variable optical zoom light optics: 100 points

c) optical resolution of 0.7 microns and flat field of view. In addition, as a particle is brought in and out of focus, it' s image shall concentrically collapse and expand without noticeable X or Y motion. **The optical image shall be clean and free from all dirt, dust and smudges.**

d) optical depth of field of less than +/- 1 um at 300 - 400 X verified using hi-res video capture images on a suitable test specimen

e) the image shift in transmitted light must be less than 1 um as the transmitted optical light polarizers are rotated. The transmitted optical system must be compatible with all sample mounting systems

f) automatic stage foccusing using the optical system or inferometer is required. The auto focussing reproducibility must be tested by performing the following test:

100 repeated auto-focusses that reproduce the stage Z position within 1 um each time on a static flat polished carbon coated Cu sample (dark blue color)

g) High sensitivity cathodo-luminescence (CL) detection system, fully integrated into the digital imaging electronics system

6. Automatic vacuum control system :

a) separate roughing and backing **direct drive** mechanical rotary pumps (Alcatel 2012A or equivalent) both at least 300 l/m pumping speed and a maximum base pressure of 10 microns or less. The Vendor must provide hose connections and in-line anti-vibration dampeners with standard ISO connections (NW25 or equivalent). Both mechanical pumps must have a MicroMaze-type recyclable filter (or equivalent dust-free filter) for trapping backstreamed oil.

b) water-cooled oil (constant operation) high throughput diffusion pump with a provision for trapping of oil vapors using a Freon cooled (or equivalent working fluid) compressor system and baffle or trap device at –40 degrees, and capable of operating the column at a pressure of 8×10^{-6} Torr (8×10^{-7} or better ***desired***) and electron gun at a pressure of 8×10^{-7} Torr (8×10^{-8} or better ***desired***) or better after 20 minute pump down with hot diffusion pump. It is ***desired*** to have an ion (using Ta/Ti bi-metal elements to avoid Ar instability) or other ultra clean high vaccum pump installed on the gun for the longest possible filament life and stable operation.

Desired: column pressure: 8×10^{-7} Torr: 50 points
Desired: gun pressure: 8×10^{-8} Torr: 50 points
Desired: Ta/Ti bi-metal ion pump on gun: 50 points

c) automatic protection against power, water supply , compressed air or vacuum failure

d) electron gun cavity and sample airlock chamber must be valved and vacuum isolatable for filament change and sample exchange

e) Uninterruptible Power Supply (UPS) using an “on-line” technology (no switching to or from batteries) for electrical system backup able to run all pumps, chiller, computers and electronics (7.2 KVA minimum) for a period of at least 5 minutes (10 minutes ***desired***). Vendor shall supply compatible UPS software and cabling to enable automatic computer system shutdown when the UPS detects an extended power outage.

Desired: 10 minutes UPS backup for all pumps, chiller, computers and electronics (7.2 KVA minimum) : 50 points

7. Specimen chamber with specimen exchange system :

a) using airlock and automated vacuum system, allowing sample or filament exchange without venting entire sample or spectrometer chamber

b) a minimum of 4 **complete** sample holders (without part exchange) shall be provided and accommodate a variety of sample shapes and sizes for :

- at least 5 (6 ***desired***) 25mm diameter round thin/thick sections (15 mm thick) simultaneously

Desired: sample holder with 6, 25 mm diameter positions: 50 points

- at least 1 (2 ***desired***) standard petrographic rectangular thin **plus** 2 25mm round thin/thick (15mm thick) sections simultaneously

Desired: sample holder with 2, standard petrographic thin section holders plus 2, 25 mm diameter positions: 50 points

- the vendor shall also include an **additional blank sample holder** to allow for non-standard size samples

c) all sample holder systems must allow observation by electron (SE and BSE) and light (reflected and transmitted) optical systems without sample or equipment change

d) sample exchange by way of airlock shall take no longer than 3 minutes (1 minute desired). Time to beam ready shall be less than 5 minutes with a dry sample.

e) It is critical that the entire gun, column and sample chamber vacuum system be assembled with high vacuum protocols, including but not limited to gloved assembly, all viton o-rings, completely degreased mechanical parts, baked to 50 degrees centigrade under vacuum for 24 hours and back-filled with dry nitrogen prior to shipment.

f) Complete and detailed mechanical assembly drawings shall be provided showing all clearances above the specimen with all dimensions given of the objective lens pole face, backscatter detector, stage mechanism, sample shuttles and suitable side access port so that UofO may fabricate an Ar plasma gun that can be inserted over the sample analysis position for cleaning hydrocarbon residue and oxidation layers.

8. Sample stage/motor system :

a) high speed and 100% reliable servo or stepper stage motors (linear optical encoder position verification desired but not required) with 0.5 um movement on all three axes. The stage must remain within 0.1 degrees level (+/- 0.05 degrees) relative to all spectrometer take off angles at all times. This shall be verified by measuring k-ratios for each spectrometer tuned to the same element (see item 3f). For this reason, there shall be NO stage tilt option in the sample stage assembly

Desired: linear optical encoder position verification for stage: 100 points

b) minimum of 5 mm/sec speed (10 mm/sec desired) and less than or equal to +/-1 micron reproducibility (+/- 0.5 micron desired) for X and Y axis positioning, and 1 mm/sec speed (2 mm/sec desired) and less than or equal to +/-1 micron reproducibility (+/- 0.5 micron desired) for Z axis positioning as determined by driving from a point of interest to stage limits and back to the point of interest at 10,000X in SE image mode for X and Y and reflected light for Z over 200 times without dicernable failure of reproducibility.

c) after the above test, the stage and beam position shift shall be less than +/- 1 micron after 30 minutes as viewed in SE at 10,000X

d) there shall be **dedicated** trackball, thumbwheels or joystick for manual stage adjustment of X and Y (and Z) axes **simultaneously** at all times

e) the sample chamber shall be supplied with a chilled baffle (cooled by a compressed working fluid at –40 degrees or better) over the diffusion pump and either or both an LN_2 cold trap finger and/or an air jet system to provide anti-contamination for the sample stage area

f) an automatic focus device or system for sample stage focusing of the optical image shall be supplied. See specification 5f.

9. Instrument control and data interface :

a) all automation, acquisition and control software interface functions of the Vendor's instrument (stage and spectrometer motor automation, PHA/counting, column/beam control, etc.) shall be specified and documented **in English**

b) complete documentation of interfaces and communication protocols to **main** instrument microprocessor(s) and/or hardware systems and subsystems shall be provided **in English** to allow UofO the option to interface directly to the probe hardware in the future. A non-disclosure agreement can be negotiated with UofO if required by the Vendor.

c) All microprobe interface functions (TCP/IP, GPIB, serial and/or Windows 32 bit DLL and/or Active-X COM software interfaces) for spectrometers, stage, counting, PHA, column control, EDS and imaging acquisition **must be documented and clearly specified**, including but not limited to microprobe interface hardware, column, stage and spectrometer configurations, also stage/spectrometer positioning, PHA bias, gain, baseline, window and mode parameters, also xray counter times and repetitions, analyzing crystal flipping, also peak search and calibration, plus EDS spectrum acquisition and peak stripping and x-ray and analog digital image acquisition. The following table will assist in determining the minimum set of functions that will be required to interface the instrument to the software used by UofO.

d) The instrument communication interface must be able to be accessed **by more than one IP address (TCP/IP interface) or asynchronous program (DLL or Active-X interface) alternately (with milli-second time slicing) without configuration changes.**

The following are the minimum interface protocols required by UofO:

Required WDS Specific Functions :

Instrument Function/Description	Values passed	Values returned
Initialize Instrument		success or error number
Shutdown Instrument		success or error number
Move Stage To Absolute Position	stage axis number, position	success or error number
Read Stage Move Status	stage axis number	boolean
Stop Stage Move	stage axis number	success or error number
Read Stage Position	stage axis number	stage position

Move Spectrometer To Absolute Position	spectrometer number, position	success or error number
Read Spectrometer Move Status	spectrometer number	boolean
Stop Spectrometer Move	spectrometer number	success or error number
Read Spectrometer Position	spectrometer number	spectrometer position

Start Spectrometer Count	spectrometer number, count time, maximum counts	success or error number
Read Spectrometer Status	spectrometer number	boolean
Read Spectrometer Count	spectrometer number	x-ray counts, elapsed time
Stop Spectrometer Count	spectrometer number	success or error number
Set (change) Spectrometer Crystal	spectrometer number, cystal	success or error number
Start Peak Center	spectrometer number, ?	success or error number
Read Peak Center Status	spectrometer number	boolean
Set PHA	spectrometer number, baseline, window, gain, bias, etc.	success or error number
Read PHA	spectrometer number	baseline, window, gain, bias, etc.

Start Autofocus		success or error number
Read Autofocus Status		boolean

Get Accel Voltage	KeV	success or error number
Get Beam Current	Current	success or error number
Get Beam Size	Size	success or error number
Set Accel Voltage	KeV	success or error number
Set Beam Current	Current	success or error number
Set Beam Size	Size	success or error number

Set Faraday	In/Out	success or error number
Read Faraday		current

Required EDS Specific Functions (only if supplied by microprobe vendor):

Start EDS Count		success or error number
Read EDS Status		boolean
Stop EDS Count		success or error number
Get EDS Parameters	pointer to pre-defined structure	detector parameters
Get EDS Spectrum (Intensities)	pointer to array	spectrum data

Get EDS Net Intensities (Off-line)	pointer to parameter structure, pointer to spectrum array, number of elements, element atomic numbers, element x-rays	net intensities

Required Imaging Specific Functions :

Setup Image Acquisition	Channel type, channel number, magnification, scan speed, dwell time, pixel dimensions, pixel averaging, frame averaging, etc.	success or error number
Start Image Acquisition		Success or error number
Read Image Acquisition Status		Boolean
Stop Image Acquisition		Success or error number
Get Image Data	Channel type, channel number	Ixpixels, iypixels, image data()
Move beam to pixel position	X Pixel/X Pixel Max, Y Pixel/Y Pixel Max	Success or error number

10. Instrument software control and data interface :

The software automation and acquisition system must fully and completely support (using digital communication access) all instrument and control features of the current instrument platforms of either the JEOL (8200) or Cameca (SX-100) instruments including imaging and EDS mechanical and electronic interfaces. In the event that a 3rd party EDS detector hardware/software systems is selected, the performance requirements of the EDS system in the attached EDS Specification document will no longer be included (Oxford Inca, Edax Genesis, etc.). This software-hardware system shall be able to both qualitatively and quantitatively analyze and image (using both WDS and EDS data) all elements from B to U and must meet the following additional requirements :

Microprobe analytical, acquisition and automation software :

a) The Vendor supplied software system must be a complete qualitative and quantitative X-ray microanalysis, image acquisition (SE, BSE, WDS and EDS X-ray, Optical), processing and analysis, data and image storage, retrieval, and graphical output, and sample stage, beam and spectrometer positioning and scanning analytical routines and all instrument control for PHA, electron column and operating hardware. It is **desired** that the Vendor's application software run on a Windows NT/2000 or XP platform.

Desired: Application software runs on Windows NT/2000 or XP: 100 points

Licenses (and any hardware copy protection devices if necessary) shall be provided for running **two** copies of the vendor software simultaneously on separate computers. This is to allow UofO to one copy for on-line for acquisition and analysis and another copy for off-line processing of spectra, calculation of quantitative data and image processing of previously acquired spectra, data and x-ray maps.

The software shall be upgraded at NO COST on a regular basis (every two years at least) to the latest version currently available.

b) All vendor software upgrades shall be provided at no extra cost to UofO for 10 years.

c) The software shall be capable of acquiring the standard calibration data in exactly the same manner (number of elements analyzed, count times (from 0.01 to 3600 seconds minimum), etc.) as the unknowns.

- it shall be possible, to have as a default option, the ability to perform a complete data acquisition on each or all standards for **all elements** in the run. The complete data for each standard shall be saved and allow for standard re-assignments and comparison of primary and secondary standard analyses.

- the concentration of elements present but not currently analyzed for, in the primary and secondary standards, shall be automatically loaded into the run configuration as elements specified by fixed concentration for each standard sample. This will facilitate the analysis of standards by allowing for the matrix correction of unanalyzed elements.

d) An export option shall produce an ASCII input file of all the required raw data, including, but not limited to :

- the sample names and types, the deadtime and beam drift corrected x-ray intensities in counts per second for all pertinent unknown samples and the actual count time for each element

- the stage coordinates, spectrometer positions (on and off-peak) and column operating conditions including, keV, beam current, beam size

- the standard compositions and deadtime and beam drift corrected x-ray intensities in counts per second and the actual count time for each element in the calibration standard(s)

- the output file created by the user written shall be displayed in the main automation/analysis program and should allow cut and paste to other applications of the calculated results

e) qualitative x-ray microanalysis software shall provide wavelength scan data acquisition, sample step-scan data acquisition (count times from 0.01 to 3600 seconds minmum), automatic peak identification for a compete K, L, M, dataset similar to the latest NIST x-ray line database (including higher order reflections), and graphical display/manipulation of data, zoom, pan, data cursor, etc.

f) wavelength scan peak identification and peak markers shall display :

- ALL (K, L, M, α, β, γ, etc.) x-ray lines capable of being generated at the current operating voltage and must also include all valid higher order reflections (up to 10th order) as well **(fully corrected for the analyzing crystal refraction index)**, in addition to all satellite lines and absorption edges.

- each x-ray line marker must be labeled using standard (Siegbahn) nomenclature (e.g., Ba Lβ_5 II for barium L-beta 5, 2nd order line)

-the height of the x-ray line markers should indicate the approximate intensity with higher orders displayed at a user defined decrease in height for each subsequent order

g) the quantitative x-ray microanalysis software shall provide complete routines for :

- instrument and standards parameters setup and recall of instrument setups from previous runs

- element and spectral line selection (Kα, Lα and Mα) standardization and calibration and recall of standard position and intensity calibrations from previous runs

- off-peak background measurement with a user option of averaged, **interpolated/extrapolated slope** (default), single side off-peak measurements and **an exponential or polynomial curved background fit**.

- manual and automated sample positioning (X, Y, and Z coordinates) for both quantitative standard and unknown data acquisition and qualitative wavelength scanning

- support for x, y and z coordinate transformation of pre-digitized standard and/or unknown coordinate files using 3 fiducial marks for translation, scaling and rotation of coordinates systems

- calculation of integrated and peak intensities for wavelength scan data (peak deconvolution of WDS data desired but not required)

h) the quantitative software options :

- the software acquisition system shall be robust (not subject to “crashes”, “hangs” or unexpected terminations at any time). No data loss shall occur at any time, even from unexpected power loss, hard disk failure (RAID 1 technology required), or operating system or application software “bug”, by the use of transactional processing database or equivalent technology. All data files shall be protected from casual deletion or inadvertent overwriting.

- the software installation shall be provided on CDROM and over the Internet for updates and new features (at no charge) for a period of up to 5 years

- provide simultaneous WDS and EDS data acquisition and be capable of accepting EDS and WDS data either alone or in combination (if EDS system is supplied by Vendor as an integrated option)

- provide capability for analysis and reduction of a minimum of 32 elements or oxides (40 desired), including calculating an element by difference, by stoichiometry, by fixing formulas proportional to oxygen and/or by including fixed concentrations of selected elements (such as carbon)

- oxide cation ratios can be defined by the user during the analytical run for the calculation of oxygen whether calculated by stoichiometry or measured; if measured the calculated oxygen must be subtracted from the measured and the difference displayed

- a standard database that can store up to 1000 standards with 32 elements (40 desired) each and include support for composition input by element weight percent, oxide weight percent (with default or user specified oxide cation ratios), mole or atomic percents or formula atoms; search for standard compositions that meet a user specified compositional range, calculate and display elemental k-ratio and matrix correction factors for each element in a specified standard; import a standard composition from an ASCII file; output selected or all standard compositions to an ASCII file

- provide correction routines for x-ray intensity data by atomic number, absorption, and fluorescence (ZAF), or x-ray emission vs. depth/density [$\phi(pz)$ or PAP]

- provide a option for different MAC (mass absorption coefficient) data (for example Heinrich vs. Henke vs. Pouchou) reference tables and allow the user the option to specify empirically derived MACs on an individual basis

- provide **quantitative** mapping (X, Y) capability using **both beam scaning and also stage scanning or grid stepping with a fixed beam** and output of calculated weight percent/atomic percent/formulas as 3-D surface plot or color flood contour plots with title and axis labels. Quantitation will be provided by referencing existing standardization intensity data with normalizations for deadtime, integration time and beam current. The quantitative imaging software will also be required to allow for correction of images for background (continuum) correction using various methods.

- be able to perform a complete multiple analysis sequence of standard and digitized unknowns (random points, traverses and x-y rectangular and polygon defined grid patterns) without operator intervention

- provide complete saving of all instrument settings and user specified analytical options to disk and the ability to recall any sample raw data for further recalculation and to allow restarting the saved run or starting a new run based on a previous run instrument setup

- a full featured quantitative thin film modeling program shall be provided that can quickly and easily import data directly from the Vendor acquisition routines **(and at least one other ASCII import format or detailed documentation must be provided for the normal binary import file format for thin film intensities)** for correction of thin films on substrates. The software shall calculate both composition and thickness iteratively (both unknown) at the same time and handle multiple films (though not with duplicated elements between the films and substrates). The software shall also be able to allow the user to specify by stoichiometry, difference or fixed composition additional elements not measured in the film and/or substrate. The software shall be able to handle up to 100 film layers on a substrate.

i) the digital imaging software shall provide for :

- digital x-ray images from 128 x 128 x 16 bits to 1024 x 1024 x 16 bits per pixel (2048 X 2048 by 16 bits per pixel desired) to be acquired using

the WDS spectrometer PHA signals and/or EDS detector ROI signals. At least 16 x-ray images must be capable of being acquired simultaneously at 512 x 512 x 16 bits per pixel. The images must be capable of being stored to hard disk or optical storage media in a TIFF or other standard image format

Desired: x-ray signal digital image at 2048 X 2048 pixels by 16 bits per pixel: 50 points

- digital image capture resolution for either BSE or SE signals must be at least 1024 X 1024 pixels by 8 bits per pixel (2048 X 2048 pixels by 16 bits per pixel desired) with output capability to hard disk or CD R/W storage media in a TIFF or other standard lossless image format

Desired: analog signal digital image at 2048 X 2048 pixels by 16 bits per pixel: 50 points

- light optical image capture and framestore capability shall be provided with output capability to hard disk or CD R/W media in a TIFF or other standard lossless image format

H. Interface acceptance tests to be performed by UofO :

The following testing of the software interface software shall be performed for evaluation of the Vendor's software and hardware at UofO :

1. Hardware Interface Tests :

a) Interface to the microprobe interface shall demonstrated by reading the availibility or value and writing the value of the following instrument configuration parameters and all errors using a test program running on a Windows NT/2000 or XP PC based platform:

- Auto focus, electron column control, electron gun control, faraday cup, high voltage control, magnification control
- Number of spectrometers, number of stages axes
- Beam current, beam defocus size
- Stage/spectrometer limits, spectrometer crystals,
- Operating conditions (accelerating voltage, beam current, faraday cup, magnification)
- Stage and spectrometer motion control (relative and absolute movement, backlash)
- Stage auto focus (start and completion)
- Spectrometer ROM based peak search, scanning and calibration
- PHA parameters (bias, gain, baseline, window and mode)
- Spectrometer crystals (read current crystal and change crystal)
- Counter (preset time, start, stop, read)
- Beam scan (conditions, start and stop)
- Stage scan (conditions, start, stop)
- Machine shutdown or filament standby
- EDS spectrum acquisition and spectrum stripping (net intensities)
- Image control and acquisition (image size (resolution), integration parameters, etc)
- Start image, get image data

I. Quantitative acceptance tests to be performed by UofO :

The following analytical tests shall be performed for evaluation of the quantitative analysis and automation system at UofO :

- replicate analysis (10 seconds counts on-peak and off-peak will be made on standards for Mg (MgO), Al (Al_2O_3), Si (SiO_2) and Fe (synthetic fayalite). This will be followed by 20 analyses of a mineral standard selected by UofO with the stage programmed to move to various points over the sample. The standard analyses will be repeated. The operating conditions will be 20 KeV and 5 - 50 nA in a fully automated mode. Automatic control of the beam current and beam focus shall be possible for both standards and unknowns during the automation.

- the raw intensities and backgrounds will be printed out along with the integrated beam current. Quantitative analyses for **all** elements in oxide weight percent of both the standards and unknowns will be printed out along with the averages, standard deviations, standard errors, P/B, k-ratios, statitical counting error, ZAF/Phi-Rho-Z correction factors and for the standards the variance from the value entered in the standard database for each element

- the mole percents, formula based on oxygen (if applicable to the sample), results in elemental weight percent (including O), detection limits at several different confidence levels and level of homogeneity will be calculated and displayed

- this procedure shall be repeated using additional elements (2 per spectrometer) and additional standards. The standards and unknown analyses will be automated and repeated at least 10 times for an overnight run without operator intervention

J. Additional Equipment Options :

In addition to the standard equipment necessary to meet the above specifications, the quotation should also include the following instrument options, unless they are already included as standard equipment :

1. A water recirculator for instrument cooling, with hot gas bypass mode for maximum temperature stability

2. A spare tungsten filament "wehnelt" assembly for quick change of the filament

3. A 1 year full coverage warranty (parts and labor) on the **entire** instrument to begin **after** the acceptance of the instrument by UofO, followed by 2 years of warranty (parts only) on the **entire** instrument.

4. A spare beam current regulation aperture assembly for quick maintenance of the column

K. Miscellaneous :

If this Purchase Order, including those documents forming a part hereof by reference or incorporation, provides for or requires the submission of any work to UofO for approval, any such approval given by UofO prior to final acceptance shall not relieve the seller of its responsibility for complying with the specifications and other provisions of this Purchase Order. Any such approval shall not be construed as an assumption by UofO of the responsibility that such work complies with or will comply with the specifications or other provisions of this Purchase Order.